Space Weather Technical Forecast

Issued on Monday, 24 April 2023 at 01:18 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Strong or Severe geomagnetic storm/G3-G4 from CME early on Day 1 (Monday 24 April). Slight chance of M-class flares (R1-R2 Minor-Moderate radio blackouts) throughout.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low over the past 24 hours, with only a few minor C-class flares observed. There are currently five numbered sunspot regions on the visible disc. AR3282 is the largest region on the disc, which is becoming difficult to analyse as it approaches the northwest limb. AR3285 in the southeast is second largest with little change. The remaining sunspot regions remain small and stable, including a new and currently unnumbered sunspot region in the far southeast.

The large full-halo CME (Coronal Mass Ejection) that left the Sun on Friday UTC evening at 21/1812UTC from an M1.7 flare and associated filament eruption from near centre-disc arrived at L1 at 23/1700 UTC. No other Earth-directed CMEs have been observed in the last 24 hours.

Solar Wind / Geomagnetic Activity: The solar wind, as observed by DSCOVR at L1 and ACE, was initially at slow-ambient levels, but increased significantly to Elevated or Strong levels, briefly reaching Very Strong levels, with the arrival of the CME, with a peak speed of near 800km/s observed at 23/2140 UTC. The solar wind density was initially below average, increasing to above average with the arrival of the CME, with a peak of 33 ppcc observed at 23/1944 UTC, before declining to below average values. The IMF was initially weak, increasing to strong or very strong with the arrival of the CME, with a peak of 31nT observed at 23/2200 UTC. The north-south component (Bz) started the period at weak levels, strengthening due to CME influence, with a maximum southward component of -25nT observed at 23/1808 UTC. The phi angle was mostly negative (towards the Sun), with brief orientations to positive (away from the Sun). The net effect of the above solar wind measures was initially Quiet (Kp1-2), with geomagnetic activity increasing to G1-G2 Minor-Moderate Storm (Kp5-6) observed between 23/1200-1800 UTC, strengthening to a G3-G4 Strong to Severe Storm (Kp7-8) between 23/1800-0000 UTC.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV) as measured at GOES16, was slightly enhanced throughout, following the M-class flare and filament eruption from 21/1812UTC, and reached above the S1 (storm level) following the arrival of the CME, with a peak value of 26 pfu observed at 23/1820 UTC. High energy electron flux (greater than 2MeV) as measured at GOES16 was mostly at Normal Background levels. The associated 24-hour electron fluence was well below the Active threshold on a steady trend, with 1.47e6 integrated pfu observed at 24/0001UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity carries a Slight Chance of isolated Moderate activity, mainly due to AR3282 but perhaps also from the AR3285 in the southeast quadrant, otherwise activity is most

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likely to remain Low.

Solar Wind / Geomagnetic Activity: Earth is currently experiencing the impacts from the full halo CME, which left the Sun on 21 Apr. Solar winds are likely to remain Elevated during day 1 (24 Apr) due to on-going CME effects, before declining to Slightly Elevated on day 2 (25 Apr), perhaps briefly reaching background levels on day 3 (26 Apr). A gradual increase to Slightly Elevated levels are likely on day 4 (27 Apr) due to the arrival of a HSS from CH96 (which is negative). Geomagnetic activity will be initially at G3 Strong Storm levels (Kp7) with further G1-G2 Minor-Moderate storms (Kp5-6) Expected on day 1 (24 Apr) due to the on-going CME effects. Geomagnetic activity gradually reducing to Unsettled or Active intervals (Kp3-4) on day 2 (25 Apr), perhaps reaching Quiet to Unsettled intervals on days 3 and 4 (26-27 Apr) as CME effects wane. However, a HSS from CH96 is Likely to arrive during day 4 (27 Apr) which may increase geomagnetic activity to Unsettled or Active intervals (Kp2-3), with Slight Chance of G1 Minor Storm (Kp 5).

Energetic Particles / Solar Radiation: High energy (greater than 10MeV) proton flux is most likely to persist at Background levels, although there is a slight chance of S1 or greater, mainly due to on-going CME effects and any significant flares, which may occur from AR3282 near the northwest quadrant. High energy (greater than 2MeV) electron flux is currently at Normal Background levels, with little change expected, although a slight increase is possible later in the period in response to HSS effects. The associated 24-hour integrated fluence is expected to remain below the Active threshold (1e8 integrated pfu), but with an increasing trend later in the period- although this may remain suppressed due to on-going CME effects.

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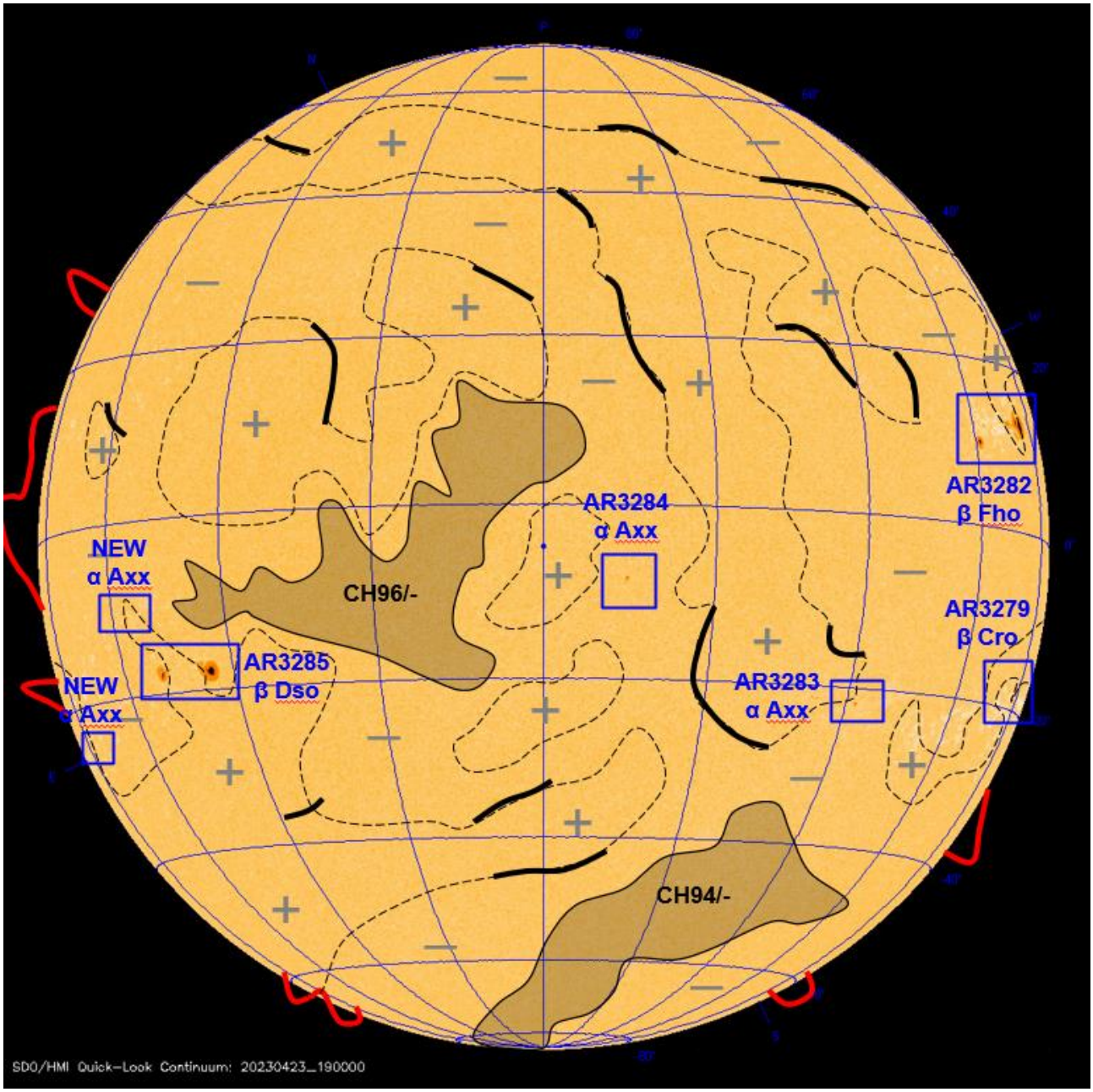
Figure 1. Solar Analysis Valid 23/1900 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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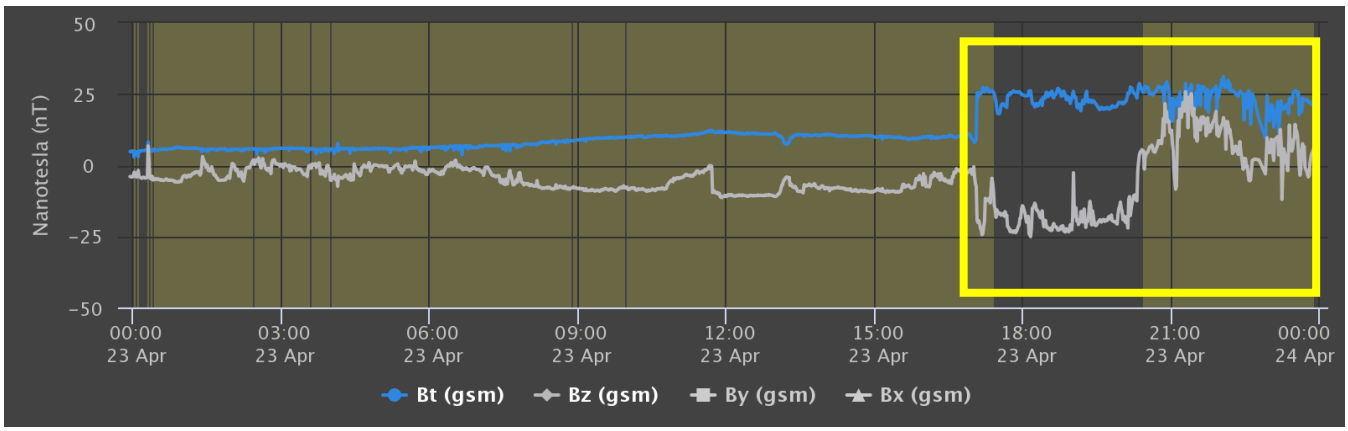
Geomagnetic Storms:

Earth is currently experiencing the impacts from the full halo CME, which left the Sun on 21 Apr, with solar winds at Elevated or Strong levels. Geomagnetic activity has recently reached G3-G4 Strong to Severe Storm (Kp7-8) levels due to the arrival of the CME. Solar winds are likely to remain Elevated during day 1 (24 Apr) due to on-going CME effects, before declining to Slightly Elevated on day 2 (25 Apr), perhaps briefly reaching background levels on day 3 (26 Apr). A gradual increase back up to Slightly Elevated levels are likely on day 4 (27 Apr) due to the arrival of a HSS from CH96 (which is negative).

Geomagnetic activity will be initially at G3 Strong Storm levels (Kp7) with further G1-G2 Minor-Moderate storms (Kp5-6) Expected on day 1 (24 Apr) due to the on-going CME effects. Geomagnetic activity gradually reducing to Unsettled or Active intervals (Kp3-4) on day 2 (25 Apr), perhaps reaching Quiet to Unsettled intervals on days 3 and 4 (26-27 Apr) as CME effects continue to wane. However, a HSS from CH96 is Likely to arrive during day 4 (27 Apr) which may increase geomagnetic activity to Unsettled or Active intervals (Kp2-3), with Slight Chance of G1 Minor Storm (Kp 5).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	90	40	10	10
Strong	G3	Yes	40	20	1	1
Severe	G4	Yes	10	1	1	1
Extreme	G5	No	1	1	1	1

Figure 2 – L1 (DSCOVR) magnetometer shows the arrival of the CME (top) and solar wind speeds (bottom).



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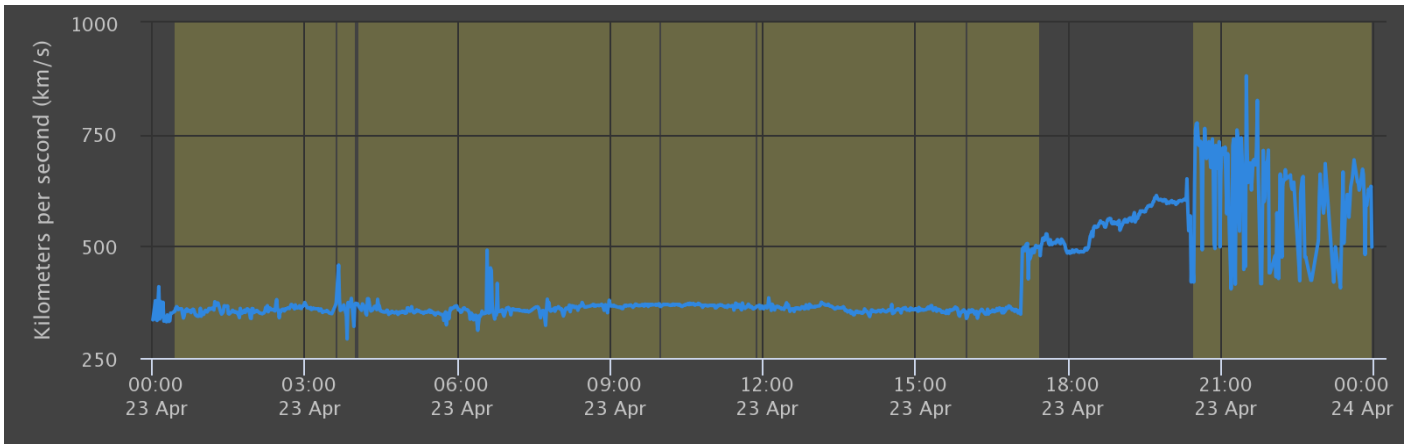
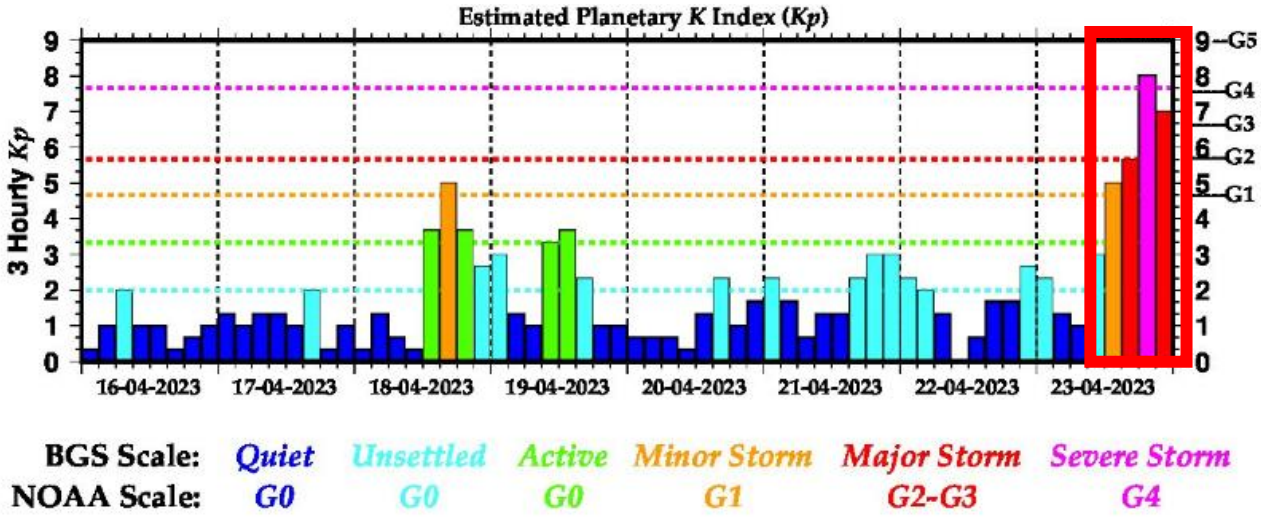


Figure 3: BGS Estimated Planetary K Index (Kp) – shows the impacts from the Full Halo CME, which left the Sun on 21 April.


Estimated Planetary K Index (Kp)
3 Hourly Kp
9 8 7 6 5 4 3 2 1 0
G5 G4 G3 G2 G1
16-04-2023 17-04-2023 18-04-2023 19-04-2023 20-04-2023 21-04-2023 22-04-2023 23-04-2023
BGS Scale: Quiet Unsettled Active Minor Storm Major Storm Severe Storm
NOAA Scale: G0 G0 G0 G1 G2-G3 G4

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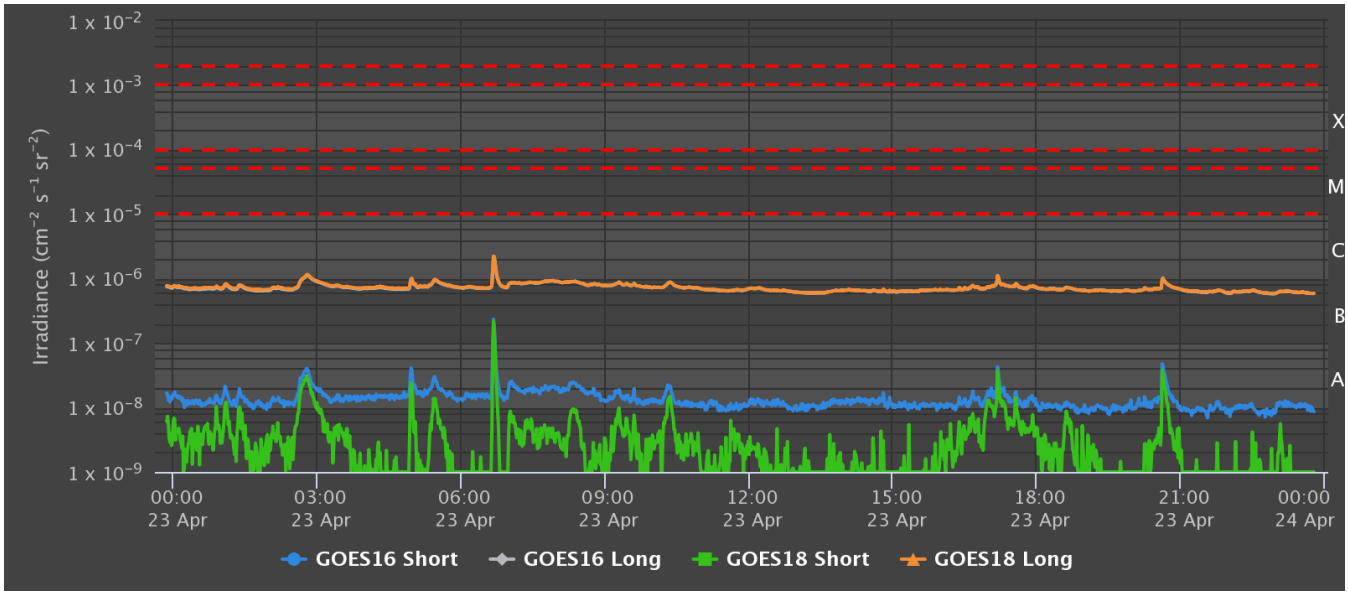
Radio Blackouts - X-Ray Flares:

There are currently five numbered sunspot regions on the visible disc. AR3282 approaching the northwest limb is the largest grouping and has lost a few more intermediate spots in recent hours. AR3285 in the southeast is second largest with little change. The remaining sunspot regions remain small and stable, including a new and currently unnumbered sunspot region in the far southeast. Far side imagery is indicating one or two new active regions could rotate across the eastern limb early in the coming week, with a slight increase in M-class flare probabilities indicated in the table. However this is balanced by the departure on AR3282 by the same time. Over the next couple of days solar activity is likely to remain Low, with a 20% chance of becoming Moderate given any isolated M-class flares. These most likely from AR3282, but perhaps also from AR3285, which comprise the two largest regions on the current disc.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	No	30	30	20	20
Very Active	R3 to R5 X Class	No	1	1	1	1

Figure 4: GOES X-Ray Flares.



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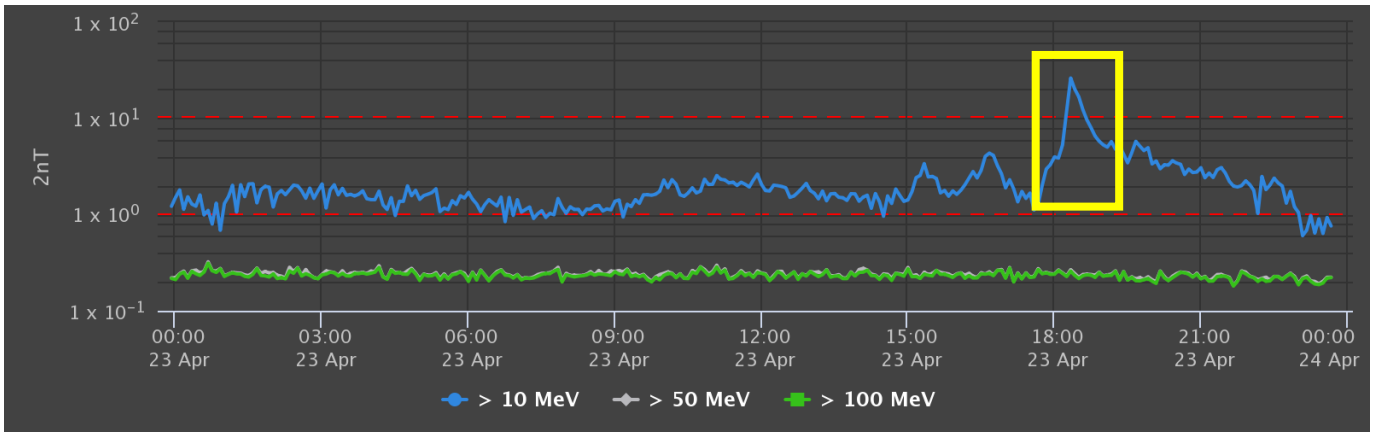
Solar Radiation Storms - (High Energy Protons):
High energy proton flux (greater than 10MeV), as observed by GOES16, was recently at Minor Storm levels (S1) due to the arrival of the large CME from 21 Apr, with a Chance of crossing the threshold again on day 1 (24 Apr), reducing to a Slight Chance throughout the remainder of the period, mainly due to AR3282, which is positioned in a favourable location in the northwest quadrant and is approaching the limb.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	Yes	50	20	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 5: GOES16 Proton Flux – shows the S1 (minor storm) threshold reached due to CME influence.



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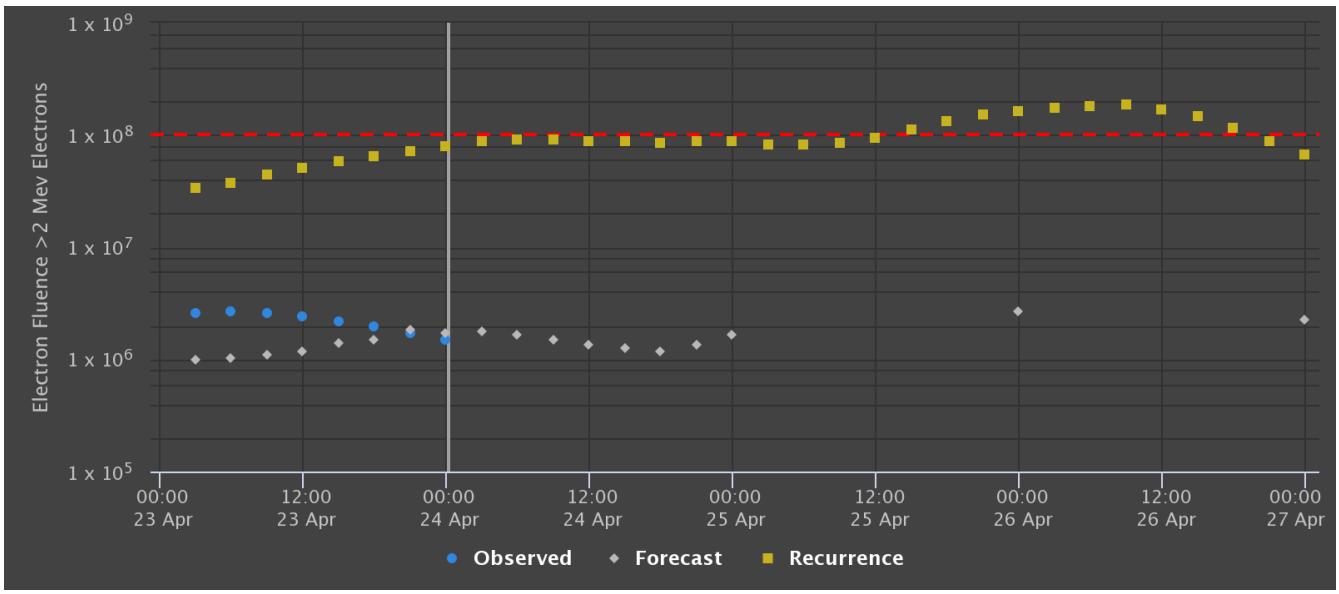
High Energy Electrons Event (≥ 2MeV):
High energy (greater than 2MeV) electron flux is currently at Normal Background levels and are likely to remain at background levels due to recent CME effects.

GEO Electron Environment	Level ($cm^{-2}\ sr^{-1}\ day^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	1	1	1	5
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 6: REFM electron fluence.



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